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SOME LITTORAL SPERMATOPHYTES OF THE NAPLES REGION.

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THE strand flora about the Bay of Naples differs so much from most of those which have been studied with reference to the toxic effect of sodium chlorid solutions that it seemed to the writer worth while to investigate the conditions of existence of a characteristic association.

Along a strip of beach sand not quite two meters above the average sea level and less than ten meters from the water line, on the margin of the Bay of Baiae, a well defined association of somewhat more than fourteen members was found. All of these occurred within a distance of a hundred meters, measured along the shore. The species determined were:

Euphorbia Paralias, E. terracina, Polygonum maritimum, Matthiola sinuata, *Alyssum maritimum, Plantago Coronopus, Medicago marina, M. litoralis, *Lotus ornithopodioides, Eryngium maritimum, Echinophora spinosa *Senecio vulgaris, *Artemisia variabilis, *Inula viscosa.

I shall refer to this group as Association A. Other species occur as members of the association, but none could be identified with certainty at the time when these studies were made (January, February, and March). The five species designated by asterisks are much more abundant in inland stations than they are as strand plants. Conspicuous members of other strand associations neighboring the one above given are: *Narcissus Tazzetta* var., *Thymelaea hirsuta*, *Glaucium flavum*, and *Verbascum sinuatum*. Out of the fourteen listed above, *Euphorbia Paralias*, *Polygonum maritimum*, *Eryngium maritimum*, and *Echinophora spinosa* are the most notably psammophilous species. All four of these are capable of growing out of drifting sand, emerging again and again as they are partially buried.

Only a few of the structural peculiarities of halophytes, as enumerated by WARMING,[1] were to be noted in the association under discussion. Studies carried through a considerable part of the year would be necessary in order to enable one to make a detailed comparison between plants of the same species found growing as members of this strand flora and further inland. The points that could be established during the months of late winter and early spring when these observations were made were as follows:

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[1] Oekologische Pflanzengeographie. Zweite Auflage. Berlin. 1902. pp. 305–308

Alyssum maritimum (littoral form): leaves with more, longer, and stouter hairs on both surfaces than occur on the ordinary form; leaves much smaller and darker green than in the ordinary form; leaves from 1.5 to 3.5 times as thick as in the ordinary form.

Senecio vulgaris (littoral form): plants very low, often with the leaves in rosette form and heads in full bloom only 2^{cm} high. The maximum height observed was 8^{cm}, while the average height of plants growing in fairly good soil further inland was (ten specimens taken at random) 35.7^{cm}. The stems of the littoral form were proportionately stouter and more hairy, and the leaves were darker green, more pubescent, thicker, more sessile (sometimes clasping and almost decurrent). The root system of plants of the littoral form is much more developed than in the ordinary form, but there are no aerial roots, such as are commonly found along the lower part of the stems of this Senecio when growing in ordinary situations.

Artemisia variabilis (littoral form): leaves with more slender divisions, the tips more strongly mucronate and the surface more scaly than the ordinary form; the young leaves of littoral plants were often densely pubescent, while I have never seen them so on plants growing in ordinary stations.

No decided differences were noted between the specimens of Inula found growing in the beach sands and those occurring elsewhere. The Lotus plants were too young to be compared with inland specimens.

The beach sand in which Association A was growing consisted of grains for the most part ranging from 0.80^{mm} to 0.30^{mm} in diameter. It was evidently mainly derived from comminuted trachyte and scoriaceous lava, probably from the little extinct volcano of Monte Nuovo close by. A sample of the sand was taken February 1 from among the roots of the *Euphorbia Paralias* and *Matthiola sinuata* and analyzed gravimetrically for chlorin. It contained 7.3 per cent. of moisture, which contained a trifle more than 0.04^{mg} chlorin per gram. In round numbers, 0.2 per cent. of the moisture was sea water. This extremely low per centage of chlorin accords with the fact that waves never in ordinary storms wash up as far as the level on which the plants were growing. They must, however, sometimes break into spray which reaches the station of the association studied. For the purpose of getting data for comparison of the salinity of the sand above described with other marine sands and soils and with ordinary garden soil, I made some further analyses, which are summarized in the table below.

	Per cent. Cl	Per cent. sea water	Per cent. water	Sea water per cent. of total water
1. Beach sand, Bay of Baiae (Association A)	0.0003	0.015	7.3	0.19
2. Beach sand, Mare Morto	0.0163	0.807	21.4	3.76
3. Beach mud, Lake Lucrinus	0.0125	0.619	52.5	2.23
4. Loam from vineyard near Pozzuoli....	0.00025		25.0	

The second column of the table shows what proportion of sea water present in the sand or mud would account for the amount of chlorin actually found. The third column gives the total moisture present, and the fourth column shows what proportion of total water in the soil was sea water. The calculations are based on the assumption that the water of this portion of the Mediterranean contains in 1,000 parts about as follows:[2] NaCl, 28.76; KCl, 0.66; MgCl, 3.25.

In the beach sand from Mare Morto (no. 2) was found an association consisting of *Polygonum maritimum*, *Salsola Kali Tragus*, and a species of grass undeterminable at this season. In the immediate neighborhood occurred occasional specimens of *Aster Tripolium* and much *Plantago Coronopus*.

In the beach mud from Lake Lucrinus (no. 3) I found no member of Association A except *Inula viscosa*. This was extremely luxuriant, with branches attaining a diameter of 4^{cm} instead of the diameter of 0.8 to 1^{cm} usual in ordinary localities. The only associates identified in the very limited area examined were *Statice Limonium*, *Ficus Carica*, and *Inula crithmoides* (?).

It is evident from the analyses given that none of the soils examined were saline in any such degree as the familiar salt marshes of the

[2] ROTH, JUSTUS, Allgemeine und Chemische Geologie 1:524. 1879.

New England coast and the maritime provinces of Canada.[3] I have not indeed been able to find any typical salt marshes in the Naples region, since the beaches are often for long distances walled or protected by riprap against the encroachment of the sea, and nearly land-locked bodies of salt water such as Lake Lucrinus and the Mare Morto are surrounded by vertical stone walls, to admit of the utilization of the adjacent land to the water's edge.

It would *a priori* seem probable that the plants of Association A would belong to the category of littoral species rather than of genuine halophytes, and the results of my cultures confirm this supposition.

It seemed to the writer that the questions most worthy of investigation in connection with the association studied were: (1) the relative sensitiveness of the species to the effect of sea water or sodium chlorid solutions;[4] (2) the relative sensitiveness of strand-grown and inland-grown specimens of the same species to the effect of such solutions.

Thrifty self-sown seedlings of the species of Euphorbia, Matthiola, and Senecio in the list of members of Association A were found in great abundance, and therefore special attention was given to these species, though larger plants of all the others which could be obtained in good condition were also studied. Sea water and pure sodium chlorid, in solutions ranging from 1 to 6 per cent. of the salt were used for the cultures. The roots of the plants were partially freed from adhering sand or earth by careful immersion in a solution of the same strength as that employed in the culture, and then the plants were transferred to small tumblers containing the culture solution in which the roots were immersed. Each tumbler was covered by a disk of waterproofed pasteboard, fitted around the protruding stems of the seedlings, sufficiently close to prevent much evaporation, but not to hinder aeration of the solution. The room temperature during the two and a half months devoted to the investigation usually ranged between 12° or 15° C. by night and 20° or 22° by day, and the plants were about 1.5^m in front of a south window 2.5^m wide.

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[3] See GANONG, W. F., The vegetation of the Bay of Fundy salt and diked marshes. Bot. Gaz. **36**:286, 292. 1903.

[4] The writer took for granted the accuracy of H. COUPIN's statement that the fatal effect of sea water upon vegetation is due to its sodium chlorid. See his article: Sur la toxicité de chlorure de sodium, etc. Rev. Gén. Botanique **10**:177. 1898.

In order to avoid the possible presence of traces of salts of copper or other injurious metals sometimes found in distilled water the solutions were made up with very pure cistern water.

Much difficulty was experienced in getting perfectly comparable results from the fact that slight individual differences in the plants (such as relative development of the root system) made decided differences in their tolerance of the saline solutions employed. Many values were discarded, from the fact that they were evidently erroneous from variations of this kind. In general, as was to be expected, the duration of life in sea water was considerably greater than in a pure sodium chlorid solution containing the same per cent. of this salt (2.88) that is found in Mediterranean sea water. Some of the principal results obtained are summarized in the following table:

ORDER OF RESISTANCE TO SALINE SOLUTIONS.

	In 2.88 per cent. solution NaCl, lived days	In 100 per cent. sea water, lived days
Euphorbia Paralias	17	20
Matthiola sinuata	16	19
Euphorbia terracina	11–13	9
Echinophora spinosa	15	7
Polygonum maritimum	9–10	
Alyssum maritimum (littoral)	8	7
" " (inland)		7
Senecio vulgaris (littoral)	3	5
" " (inland)		5

It is noteworthy that the littoral and the inland specimens of Alyssum and of Senecio were equal in their resisting power, as might have been expected from the comparatively equal amounts of chlorid in the beach sand and the vineyard soil.

Some experiments were made to ascertain the maximum per cent. of seawater which could be tolerated by the species of Association A without speedy appearance of symptoms of injury, such as partial drying up or death of shoots. Difficulty was found in discriminating between retardation of growth and weakening caused by culture under artificial conditions, and that due solely to the excessive salinity of the culture solutions. It was considered that a plant was unharmed if it showed no decided ill effects from the solution (except retarded growth) after the culture had continued for a month. The results appended are only approximate.

PER CENT. OF SEA WATER TOLERATED WITHOUT SPEEDY INJURY.

Matthiola sinuata	75
Euphorbia Paralias	63
Echinophora spinosa	50 or more
Polygonum maritimum	50
Euphorbia terracina	50 or less

For the sake of comparison a few cultures were made of species growing in full sunlight in the vineyard the soil of which was analyzed for chlorin as above given. All soon succumbed to the effect of 50 per cent. sea water (and in general still more readily to 1.5 per cent. sodium chloride solution). Classed according to the readiness with which they wilted and then died, their sensitiveness to the salts in solution was about in the following order.:

1. Lamium amplexicaule.
2. Fumaria Gussonii.
3. Papaver Rhoeas.
4. Polygonum aviculare monspeliensis.
5. Veronica Tournefortii.
6. Geranium molle.
7. Rumex bucephalophorus.
8. Euphorbia Peplus.
9. Anthemis arvensis var.

Roughly speaking, the order above given is that in which these annuals wither and die at the onset of the summer drought, except as regards no. 3, which persists well into the dry season.

In order to compare the behavior of the plants of Association A with that of true halophytes, cultivated in saline solutions, some seedlings of *Salsola Kali Tragus* were procured from the sand adjacent to Mare Morto, above described. The plants were $2\text{–}2.5^{\mathrm{cm}}$ high and cultures were made of these in clean sand, rinsed with the saline solution to be used, and then flooded once a day with another portion of the solution, which was afterwards poured off. The concentrations employed were respectively of 4, 5, 5.5, 6, and 7 per cent. of sodium chlorid, and other specimens were cultivated in solutions without sand.

In sand the plants appeared normal up to and including 6 per cent. sodium chlorid solution, though growth was slow for all concentrations above 4 per cent. Without sand prompt loss of turgor was noticed in 6 per cent. solution, corresponding pretty nearly to that observed in the solution of 7 per cent. with sand. This diminished effect of the salt in the presence of sand is in accordance with the conclusions of TRUE and OGLEVEE[5] in regard to the lessened effect of toxic substances in aqueous solution in presence of inert and insoluble solids.

None of the work done was shaped with special reference to determining whether the injurious action of saline solutions on the plants examined was due to dehydrating or other physical effects, or whether it was purely toxic. A notable desiccation and shrinkage was often observed throughout the stem while the upper leaves and especially the terminal bud remained vigorous. This fact would tend to confirm the hypothesis that the lethal action of dissolved salts is of a physical character. On the other hand, the fact that a pure sodium chlorid solution is usually more quickly fatal than sea water containing the same amount of sodium chlorid plus other salts tends to confirm the toxic hypothesis. Probably both factors may cooperate to produce death. Apparently the relative ease with which root hairs of the species studied can be plasmolyzed does not bear any definite relation to the susceptibility of the species to the action of sodium chlorid solutions.

The principal conclusions reached may be summarized as follows:

1. Association A consists of members very unequally resistant to the action of pure sodium chlorid solutions and of sea water.

2. The tolerance of sodium chlorid on the part of some members of this association is considerably greater than that of ordinary non-littoral plants; in other words, they are facultative halophytes.

3. Many of the species of this association are typical psammophytes, none are typical halophytes.

4. Growth of a non-halophytic species for many generations in an atmosphere at times highly charged with saline spray does not bring about greater tolerance of saline solutions when absorbed by the roots.

5. The Salsola seedlings studied showed a tolerance of sodium chlorid solutions up to almost 6 per cent. as good as that of any member of Association A for the 2.88 per cent. solution.

NAPLES, ITALY.

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[5] TRUE R. H., and OGLEVEE, C. S., The effect of the presence of insoluble substances on the toxic action of poisons. Bot. GAZETTE **39**: 1–21. 1905.